Marks

1. (a) (i) At equilibrium, length submerged = x_0

$Ax_0(1000)g = A(0.20)(800)g$

$x_0 = 0.16$ m — 1

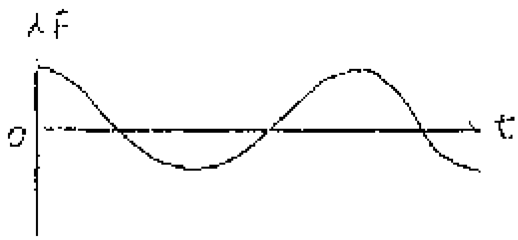
(ii) Suppose the object is submerged for length $x + x_0$.

Resultant force $= A(0.20)(800)g - A(x + x_0)(1000)g$ — 1

$= -x$ — 1

(another mark for -ve sign) — 1

(iii)



sine curve — 1

t = 0, F at max (+ve or -ve) — 1

(iv) $m\ddot{x} = -x \quad \therefore T = 2\pi\sqrt{m} = 2\pi\sqrt{\frac{16}{1000}}$ s — 1

≈ 0.79 s or 0.80 s — 1

(v) Max. amplitude = 0.20 − 0.16 = 0.04 m — 1

Beyond this, the cylinder is completely submerged; restoring force ceases to be proportional to x. — 1

(vi) In a wide container, KE (water) can be neglected; — 1
PE(cylinder) + KE(cylinder) + PE(water) = constant. — 1

(b) (i) Damped SHM — 1
energy transformed to internal energy of water and cylinder, temperature rises. — 1

(ii) System unstable : any deviation from vertical not subject to restoring torque. — 1

Cylinder would fall over and end up floating on its side. — 1

2. (a) $$pV = nRT$$

$$(1.01 \times 10^5)\frac{m}{(1.43)} = 1(8.31)(273)$$ 1

$$m = \frac{1(8.31)(273)(1.43)}{(1.01 \times 10^5)} = 0.0321 \text{ kg}$$ 1

(b) (i) $$n = n_1 + n_2$$

$$pV = p_1V_1 + p_2V_2$$ 1

$$(20 \times 10^5)(0.5) = (10^5)(5) + p_2(0.5)$$ 1

$$p_2 = 5 \times 10^5 \div 0.5 = 10^6 \text{ Pa}$$ 1

(ii) $$(20 \times 10^5)(0.5) = (10^5)(V_1) + (10^6)(0.5)$$ 1

$$V_1 = 9.5 \text{ m}^3$$ 1

(iii) If very slow inflation 1
permits heat exchange with surroundings 1
∴ temperature constant

Marks

3\. (a) The 2 beams of light travel different paths — 1

constructive interference for p.d. = $m\lambda$ and
destructive interference for p.d. = $(m + 1/2)\lambda$ — 1

(b) Change in optical p.d. $= 2t\ (n - 1)$ — 1
$= m\lambda$

$$t = \frac{7 \times 480}{2 \times 0.45}\ \text{nm}$$ — 1

$= 3730$ nm — 1

(c) (i) As M_2 is moved, path difference between the 2 beams is increased; a shift of fringes is observed. — 1

(ii) $2d = m\lambda$ — 1

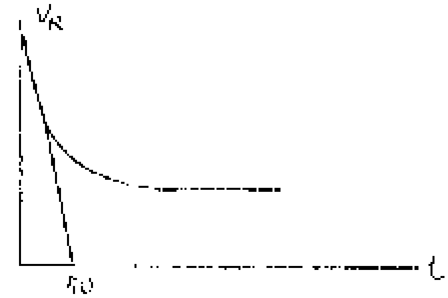
$d = \frac{800}{2} \times 480\ \text{nm} = 0.192\ \text{mm}$ — 1

(d) Since the two wavelengths differ by 0.6 nm, the interference patterns from these wavelengths will not always overlap. — 1

The interference pattern disappears when the dark fringes from one of the wavelengths fall on the bright fringes of the other. — 1

The pattern reappears when the bright fringes from the two wavelengths coincide again. — 1

4. (a)



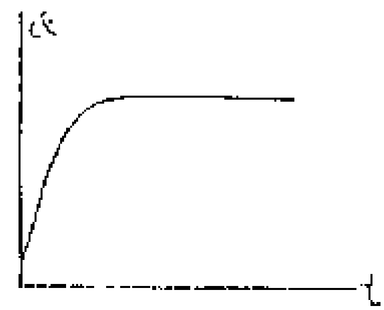
straight line with −ve slope 1
cuts t-axis at 50 s 1

(b) Theoretically, charge accumulated at uniform rate, V_C increases linearly; V_R drops linearly. 1

V_R approaches a constant value means that the p.d. across the capacitor, and hence the charge stored in it, also becomes steady. 1

At this stage, the current will not charge up the capacitor any further but will be all leaking away, i.e. an equilibrium state has been reached. 1

(c) (i)



ordinary charging curve 1
achieves a constant value later 1

(ii) At equilibrium, $V_R = 2.4$ V

P.d. across capacitor $= (12 - 2.4)$ V

$= 9.6$ V 1

Hence, charge stored on capacitor

$= (500 \times 10^{-6})(9.6)$ C 1

$= 4.8 \times 10^{-3}$ C 1

(iii) Since p.d. across capacitor at equilibrium = 9.6 V and leakage current = 120 μA.

$$\text{Leakage resistance} = \frac{9.6}{120 \times 10^{-6}}\ \Omega$$ 1

$= 80$ kΩ 1

5. (a) (i) The result shows that the induced e.m.f. in the search coil is proportional to $1/r$.
$B \propto 1/r$ for a long, current carrying, straight wire. 1

(ii) When the distance of the search coil from the straight wire is comparable to the finite length of the wire, 1
the induced e.m.f. is less than it should be for a infinitely long wire. Therefore, those data points lie above the fitted straight line. 1

(b) (i) $B = \mu_0 I/2\pi r = \mu_0 I_0 \sin(2\pi ft)/2\pi r$
$\text{emf} = NA \dfrac{dB}{dt}$ 1

$= (\mu_0 NAI_0 f/r) \cos(2\pi ft)$ 1

$V = 2\mu_0 NAI_0 f/r$ 1

(ii) slope of line $= 1800\ V^{-1} m^{-1}$ 1

$= 1/(2\mu_0 NAI_0 f)$ 1

$$N = \frac{1}{2 \times 1.26 \times 10^{-6} \times 3.14 \times 10^{-4} \times 14.1 \times 50} \text{ turns}$$

$\cong 1000$ turns 1

(c) His argument is wrong. 1

The earth's magnetic field is more or less a steady, low intensity field 1
which would not give rise to any measurable induced e.m.f. in the search coil. 1

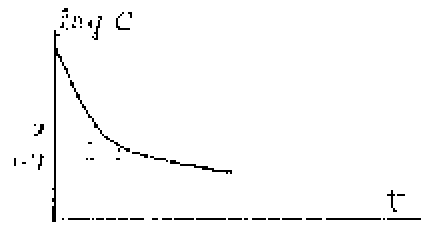
Marks

6. (a) After several days, the activity of iodine-133 has decreased to an insignificant level, 1

leaving only the activity of iodine-131 to be shown up on the decay curve 1

which when plotted on a log-scale, is a straight line. 1

(b)



$N = N_0 e^{-\lambda t}$

$\Rightarrow$ slope of line

$= \frac{\ln 2}{T} \log_{10} e$

$= 0.375 \text{ day}^{-1}$

$T_{\frac{1}{2}} \simeq \dfrac{\ln 2 \times \log_{10} e}{0.375}$

$= 8$ days

Extrapolate the straight portion to find the initial activity of I-131 to be $10^2 = 100$ cpm. 1

find time corresponding to $N = \frac{1}{2} \times 100$ or $\log N = 1.7$. 1

half-life of I-131 is 8 days. 1

(c) (i) initial count-rate for I-131, $C_1 = 10^2$ cpm

initial count-rate for I-133, $C_2 = 10^{2.9} - 10^2$ cpm 1

$= 694 \cong 700$ cpm 1

(ii) count-rate $\simeq dN/dt = \lambda N$

knows $C_1/C_2 = \lambda_1 N_1 / \lambda_2 N_2$ 1

knows $\lambda_1/\lambda_2 = T_2/T_1$ 1

knows $m_1/m_2 = 131\ N_1/133\ N_2$ 1

$$m_1/m_2 = \frac{131}{133} \times \frac{N_1}{N_2}$$

$$= \frac{131}{133} \times \frac{C_1}{C_2} \times \frac{2}{1}$$

$$= \frac{131}{133} \times \frac{C_1}{C_2} \times \frac{T_1}{T_2}$$

$$= \frac{131}{133} \times \frac{100}{700} \times \frac{8 \times 24}{20.8}$$

$= 1.30$ 1